ROOTSTOCKS TO MEET FUTURE CHALLENGES OF THE AUSTRALIAN WINE INDUSTRY



FINAL REPORT to
GRAPE AND WINE RESEARCH & DEVELOPMENT CORPORATION

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Principal Investigator: **Peter Clingeleffer**

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Author details: Peter Clingeleffer and Brady Smith (deceased)
CSIRO Plant Industry
PO Box 350, Glen Osmond SA 5064, Australia

peter.clingeleffer@csiro.au

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1. Abstract

CSIRO rootstock germplasm resources and grafted, replicated trials developed through co-investment by CSIRO and GWRDC in previous projects (CSP 99/02 and CSP 05/03) have been maintained for 2 years to underpin future rootstock research including development of new rootstock genotypes. The rootstock germplasm material included core rootstock variety and species material; ungrafted seedling populations; rootstock trials established with promising genotypes, including drought tolerant selections in Sunraysia and Padthaway; and, new rootstock genotypes which have been shown to have good nematode and phylloxera resistance, good production and wine quality characteristics, and having potential for wider scale industry evaluation.

2. Executive Summary

GWRDC and CSIRO through co-investment in previous projects have committed to delivering improved rootstocks to secure the development of an economically sustainable, resilient Australian wine grape industry. Anticipated ongoing redevelopment of vineyards previously planted on own roots provides a significant opportunity for adoption. To underpin future rootstock research and development of new rootstock genotypes, this project maintained key rootstock germplasm resources and grafted, replicated trials developed in prior projects (CSP 99/02 and CSP 05/03) for 2 years. The rootstock germplasm material included core rootstock variety and species material; ungrafted seedling populations established in the field; rootstock trials established with promising genotypes, including drought tolerant genotypes in Sunraysia and Padthaway; and, new rootstock genotypes which have been shown to have good nematode and phylloxera resistance, good production and wine quality characteristics, and having potential for wider scale industry evaluation. For the rootstock trials in bearing, yield and yield component and maturity data were collected from the replicated trials to ensure complete data sets are available for analyses in future research. There has been ongoing interaction by project personnel to communicate the results from previous rootstock research to industry and the wider research community, with publication of a number of papers in scientific, conference and industry journals.

3. Background

GWRDC and CSIRO through co-investment in previous projects have committed to delivering improved rootstocks to secure the development of an economically sustainable, resilient Australian wine grape industry. Anticipated ongoing redevelopment of vineyards previously planted on own roots provides a significant opportunity for adoption. Adoption of rootstocks will play a major role in the development of a profitable and resilient wine industry in these regions and potentially, contribute to the production of wines with lower alcohol contents. To underpin future rootstock research and including the development of new rootstock genotypes, this project has maintained key rootstock germplasm resources and grafted, replicated trials developed in prior projects (CSP 99/02 and CSP 05/03) for 2 years.

Despite the industry downturn, there is an ongoing demand for rootstocks in Australia with about 5 million cuttings sold in 2008, with a trend to the use of a diverse range of rootstocks (i.e. based on cuttings sales for 2007-2011, 1103 Paulsen, 43%; Ramsey, 15%; 101-14, 10%; and 140 Ruggeri, 16%) compared to Ramsey (53%) and Schwarzmann (18%) in the period 1989-1993. The commonly used rootstocks, developed in the Northern Hemisphere, where soils have lower potassium availability, tend to have high potassium uptake and high vigour leading to high juice pH, poor organic acid composition and colour under Australian conditions. Similarly, the predominant pathogenic root-knot nematodes in the Northern Hemisphere are *Meloidogyne incognita* and *M. arenaria*, whereas *M. javanica* is the most prevalent in Australia. Three of the six most widely used rootstocks in Australia, representing 46% of rootstock sales in 2008, are susceptible to *M. javanica*. The breeding parent *Vitis cinerea* is an excellent source of nematode resistance and is potentially also a source of phylloxera resistance. Furthermore, given the increased emphasis on tolerance to drought, a number of promising drought tolerant rootstock genotypes have been generated from various *Vitis* species.

Recent seasons in which wine grape production has been impacted by limited water supply have highlighted issues around industry resilience and the need for rootstocks that not only have high levels of pest tolerance and lead to high quality wines, but are also water use efficient, drought and salt tolerant and take up less potassium. Rootstocks with low potassium uptake offer a solution to problems of high juice and wine pH and associated negative impacts on wine quality. Issues with phylloxera outbreaks and the lack of nematode resistance of commonly

used rootstocks highlight the need. Rootstocks also offer considerable potential to address the requirement to reduce the alcohol content in Australian wines through positive impacts on the balance between sugar and flavour ripening.

The ability to redevelop existing vineyards and minimise the impacts of soil borne pests, particularly root-knot nematodes, and utilise existing infrastructure will be of significant economic benefit and provide a significant environmental benefit compared to development of vineyards in new locations. Rootstocks with moderate vigour will be key components of improved vineyard design and management involving higher density plantings to further improve production efficiencies and reduce water losses associated with soil water evaporation. Adoption of rootstocks with enhanced fruit and wine quality attributes will enable targeting of sales at higher price points and lower alcohol contents, and include potential for development of new markets. New rootstocks with low potassium uptake and subsequent reductions in must pH will reduce winemaking costs and improve wine quality attributes. Significant environmental benefits should ensue from the adoption of new rootstocks which are water use efficient, drought and salt tolerant. Furthermore, adoption of improved vineyard design and management involving higher density plantings and the use of moderate vigour rootstocks will not only improve production efficiencies but have significant environmental benefits associated with optimal use of land and water.

4. Project Aims and Performance targets

The project aimed to maintain key rootstock germplasm resources developed in previous projects and grafted, replicated trials developed in prior projects through co-investment by CSIRO and GWRDC (CSP 99/02 and CSP 05/03) for 2 years to underpin future rootstock research and development of new rootstock genotypes. The rootstock germplasm material included core rootstock variety and species material; ungrafted seedling populations established in the field; rootstock trials established with promising genotypes, including drought tolerant genotypes in Sunraysia and Padthaway; and, new rootstock genotypes which have been shown to have good nematode and phylloxera resistance, good production and wine quality characteristics, and having potential for wider scale industry evaluation. The table of outputs and activities for the project are provided below.

2011-12

	Output	Target Date	Activities
A	Established rootstock germplasm and grafted rootstock trials maintained.	30/06/2012	Routine vine pruning, irrigation, fungicide sprays and where appropriate, crop removal, applied to all rootstock germplasm plantings and rootstock trials in Sunraysia, Nuriootpa and Padthaway
B	Establishment of grafted rootstock trials, planted as part of CSP 05/03, progressed.	30/06/2012	Vine training undertaken to establish cordons for grafted rootstock trials, planted in Sunraysia and Padthaway.
C	Drought tolerant rootstock genotypes, identified as part of CSP 05/03, established at the CSIRO Sunraysia site.	30/06/2012	300 drought tolerant rootstocks propagated and planted in Sunraysia
D	Key rootstock populations established at the CSIRO Sunraysia site.	30/06/2012	Material from crosses for nematode, phylloxera and salt tolerance, including segregating populations, propagated and planted in Sunraysia
E	Promising rootstock genotypes established at the CSIRO Sunraysia site and at Nuriootpa.	30/06/2012	Material from promising rootstock genotypes with confirmed nematode and phylloxera tolerance and multiple screening studies propagated and planted in Sunraysia and/or Nuriootpa

2012-13

	Output	Target Date	Activities
A	Established rootstock germplasm and grafted rootstock trials maintained.	30/06/2013	Routine vine pruning, irrigation, fungicide sprays and where appropriate, crop removal, applied to all rootstock germplasm plantings and rootstock trials in Sunraysia, Nuriootpa and Padthaway.
B	Establishment of grafted rootstock trials, planted as part of CSP 05/03, completed	30/06/2013	Vine training and pruning undertaken to complete establishment of grafted rootstock trials, planted in Sunraysia and Padthaway.
C	Drought tolerant rootstock genotypes, identified as part of CSP 05/03, established at the CSIRO Sunraysia site.	30/06/2013	300 drought tolerant rootstocks trained and established on trellis in Sunraysia.
D	Key rootstock populations established at the CSIRO Sunraysia site.	30/06/2013	Material from crosses for nematode, phylloxera and salt tolerance, including segregating populations, trained and established on trellis in Sunraysia
E	Promising rootstock genotypes established at the CSIRO Sunraysia site and at Nuriootpa	30/06/2013	Material from promising rootstock genotypes with confirmed nematode and phylloxera tolerance and multiple screening studies established on trellis in Sunraysia and/or Nuriootpa

5. Method

The project maintained rootstock germplasm resources and grafted rootstock trials at the CSIRO Sunraysia site, SARDI Nuriootpa site and at a commercial site at Padthaway. The material included 'near to release', parental and 'pipeline material', including segregating lines for inheritance and marker studies, collectively representing an important resource for future delivery of new nematode and phylloxera tolerant rootstocks with other high priority industry-required characteristics. In order to secure the material for retention, mist and glasshouse propagation, planting and establishment of selected rootstock genotypes from Merbein-based populations or Adelaide-based glasshouse screening trials was undertaken. The key germplasm resources and associated tasks included:-

- Maintenance of rootstock seed sources from targeted breeding held under refrigeration at the CSIRO Waite campus.
- Maintenance of the rootstock variety and species collection at the CSIRO Sunraysia site and some material already established at Nuriootpa for 'ready access' from Adelaide.
- Establishment and maintenance of drought tolerant genotypes (i.e. approx. 300) at the CSIRO Sunraysia site.
- Establishment and maintenance of key rootstock populations from targeted breeding at the CSIRO Sunraysia site. These include those generated for nematode and phylloxera resistance using *Vitis cinerea* and segregating populations for nematode, phylloxera and salt tolerance.
- Establishment and maintenance of promising rootstock genotypes used in grafted vine trials, with confirmed nematode and phylloxera tolerance, and other selected genotypes from multiple screening studies, at the CSIRO Sunraysia site and/or Nuriootpa.
- Vine training and cordon establishment for planted rootstock trials including newly established trials at the CSIRO Sunraysia site and at Padthaway to maintain vine growth and health.

6. Results/Discussion

Output A

Rootstock trials and rootstock germplasm have been maintained at the CSIRO Sunraysia site, the Nuriootpa SARDI site and the commercial Padthaway site with routine management practices applied (i.e. pruning and training, irrigation, fungicide sprays). All rootstock germplasm established at the CSIRO Sunraysia site, which was previously located at CSIRO Merbein, has been trained and established with bi-lateral cordons on a single wire to facilitate simple mechanical pruning by tight hedging, for long term maintenance.

Furthermore, to maintain full data sets for future analysis, vines of Chardonnay, Cabernet Sauvignon and Shiraz, grafted on the 4 most promising rootstock selections identified from 26 selections in the previous project (CSP 05/03), and appropriate control rootstocks, were harvested to provide underpinning productivity data if one or more of these selections are released for commercial assessment in a future project. Berry weight and maturity samples were also taken at harvest. In addition, pruning weights of these selections and the control rootstocks were recorded.

For the trial grafted with Shiraz which was established at Padthaway with the 26 genotypes in the previous project (CSP05/03), the irrigation lines have been replaced because the existing lines had problems with uniformity of water application due to blockages associated with salt encrustation. As a consequence, vigour uniformity and growth of younger plantings has significantly improved. The vines have been retrained with permanent quadri-lateral cordons on a T-trellis. This trial produced a significant crop in the 2012/13 season. At harvest in 2013, bearing vines were sampled to determine maturity and berry weight and yields were recorded to ensure a complete data set will be available for future analysis as the site comes into full bearing.

Output B

Vine training and cordon establishment of new rootstock trials grafted with Shiraz and planted at the CSIRO Sunraysia site and in a commercial site in Padthaway in spring 2010 has been ongoing. The trial in Sunraysia, containing rootstock 54 genotypes, is now fully established with bi-lateral cordons on a high single wire. Application of irrigation treatments (i.e. fully watered and deficit treatments) to confirm drought tolerance of grafted selections commenced

in the 2012/2013 season. This was achieved using drip line fitted with high and low volume emitters (i.e. 1.6 and 0.7 L/hr). It produced a significant crop in season 2012/13. At harvest in 2013, bearing vines were sampled to determine maturity and berry weight and yields were recorded to ensure a complete data set will be available for future analysis as the trial site is evaluated in the future.

At Padthaway, the trial with 52 rootstock genotypes grafted with Shiraz has been trained with most vines established on a quadri-lateral cordon on a T-trellis. The good establishment of the grafted vines has been facilitated by improvements to the irrigation system identified above.

Output C

Approximately 200 ungrafted drought tolerant selections, identified in hybrid seedling populations planted at the CSIRO Merbein site and maintained without irrigation for two seasons under drought conditions (2008/09 and 2009/10) have been propagated, planted and established on the CSIRO Sunraysia site. Some selections were eliminated due to poor rooting and low vigour. This material has been been trained and established with bi-lateral cordons on a single wire to facilitate simple mechanical pruning by tight hedging, for long term maintenance.

Output D

Rootstock material from previous crosses for nematode, phylloxera and salt tolerance, which were established as seedling populations at CSIRO Merbein, including segregating populations for molecular and marker development studies, have been propagated and planted at the CSIRO Sunraysia site. In total, approximately 600 genotypes have been established from the categories listed for use in future studies. Training of these vines has been ongoing. In general, this material has also been trained and established with bi-lateral cordons on a single wire to facilitate simple mechanical pruning by tight hedging, for long term maintenance. Some material with higher planting densities was established on a single uni-lateral cordon.

Output E

Four promising rootstocks with potential for commercial release, identified in the previous project (CSP 05/03) based on performance characteristics of grafted vines under limited water supply with good phylloxera and nematode tolerance have been planted at the CSIRO Sunraysia site and the SARDI site at Nuriootpa to provide source material if the selections are released for commercial assessment. Training on bi-lateral cordons has been completed at

both sites. In addition, the selections have been provided to licensed nurseries in South Australia and Sunraysia, with appropriate testing agreements, to assess propagation characteristics under commercial conditions. The testing agreements prohibit distribution of propagation material or plants, and permit testing only. Good rooting and growth characteristics have been reported by one of the commercial nurseries.

Further data to complete assessment of key characteristics of the 4 promising selections undertaken in CSP 05/03 were also collected and provided in the updated table below. The results indicate confirmation that these selections have moderate to high vigour, are resistant to both species of nematodes tested (i.e. *M. javanica* and *M. incognita*), generally have high phylloxera tolerance, moderate to high chloride exclusion and excellent propagation characteristics.

Table 1. Vigour, nematode resistance, phylloxera tolerance, chloride exclusion and rootstrike of 4 potential new rootstock genoptypes under evaluation

Rootstock	Vigour Potential	Nematode* resistance	Phylloxera tolerance	Chloride exclusion	Root strike
C20	moderate to high	resistant	high	moderate to high	90%
C29	low to moderate	resistant	high	moderate	92%
C113	moderate to high	resistant	Moderate	high	96%
C114	high	resistant	High	high	99%

***** response to both *M. javanica* and *M. incognita*

7. Outcome/Conclusion

Key CSIRO rootstock germplasm resources and grafted, replicated trials developed in prior projects through co-investment by CSIRO and GWRDC (CSP 99/02 and CSP 05/03) have been maintained for 2 years to underpin future rootstock research and development of new rootstock genotypes. The rootstock germplasm material included core rootstock variety and species material; ungrafted seedling populations established in the field; rootstock trials established with promising genotypes, including drought tolerant genotypes, in Sunraysia and Padthaway; and new rootstock genotypes which have been shown to have good nematode and phylloxera resistance, good production and wine quality characteristics with potential for wider scale industry evaluation. Where appropriate, yield and yield component and maturity data were collected from the replicated trials to ensure complete data sets are available for analyses in future studies. There has been ongoing interaction by project personnel to communicate the results from previous rootstock research to industry and the wider research community, including publication of a number of papers in scientific, conference and industry journals.

8. Recommendations

Key rootstock germplasm resources developed in previous projects and grafted, replicated trials developed in prior projects (CSP 99/02 and CSP 05/03) have been maintained for two years to underpin future rootstock research and development of new rootstock genotypes. It is recommended that this material be evaluated in future research to identify new rootstock genotypes for release to industry. A new GWRDC project, 'New rootstocks for Australian conditions, CSP 1304 will commence in July 2013.

9. Appendix 1: Communication

In the longer term, the Australian wine grape industry is the target audience for the adoption and assessment of new rootstock material. It is envisaged that a key output from future investment will be the release of new rootstocks, which have been maintained in this project, for assessment by the wine grape industry. While there was no requirement to communicate results to industry from this maintenance project, key project personnel have been actively involved in communicating rootstock research results to industry and the wider research community. These have included presentations by Brady Smith to the Crush 2011 and Crush 2012 Symposia, to California State University in Fresno, California, Orlando Wines and to a grower group in Mornington, Victoria. Peter Clingeleffer gave presentations to the ASVO Below Ground Seminar, Mildura, July 2011, the 17th GiESCO Symposium in Asti-Alba(CN), Italy in September 2011 and Langhorne Creek growers as part of the AWRI road show. He is also the convenor of a rootstock workshop at the 15th Australian Wine Industry Technical Conference in July 2013. The researchers also provided input into the GWRDC rootstock review conducted by John Whiting. Communication has been maintained with the 2 licensed nurseries provided with 6 rootstock genotypes identified with potential for release to industry in previous projects (CSP 05/03 and CSP 10/02) in regard to assessment of propagation characteristics. Over the course of the project, three new research and two conference papers and one industry article have been published with input from project personnel based on outputs from previous projects (see references below).

10. Appendix 2: Intellectual property

This project maintained, for future research and potential delivery to industry, the considerable amount of valuable and unique IP, relating to the development of new rootstock material, which had been generated through co-investment by CSIRO, GWRDC and HAL in previous projects (CSP 99/02, CSP 05/03). This material included:-

1. Seed generated from unique species/rootstock material collected to enter into the rapid screening phase
2. Seed generated to provide segregating populations for further study of the inheritance of nematode and phylloxera resistance and molecular marker development.
3. Unique multi-species breeding lines which have or will be established as ungrafted seedling material in the field for further assessment at the CSIRO Sunraysia site, and in some cases at the SARDI Nuriootpa site. These include a diverse range of drought tolerant types indentified in CSP 05/03.
4. A unique hybrid population generated for studies of salt tolerance (CSP 10/02).
5. Core rootstock material, which has or will be established in multiplied plantings at the CSIRO Sunraysia site and in some cases, Nuriootpa to facilitate potential release for industry evaluation once the assessment of established, grafted rootstock trials is completed. This includes 5 highly promising nematode and phylloxera tolerant selections with good vineyard performance under limited water supply identified in CSP 05/03 and drought tolerant selections recently established in new grafted trials.

11. Appendix 3: References

Over the course of the project, three new research and two conference papers and one industry journal article have been published with input from project personnel based on outputs from previous projects. These are listed below for information.

Smith, B.P., Morales, N.B., Thomas, M.R., Clingeleffer, P.R. (2012) Screening of grapevines for resistance to the root-knot nematode *Meloidogyne javanica*. Australian Journal Grape and Wine Research. (accepted May 2013).

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Korosi, G.A., Powell, K.S., Clingeleffer, P.R., Smith, B., Walker, R.R. and Wood, J. (2011). New hybrid rootstock resistance screening for phylloxera under laboratory conditions. Acta Horticulturae. 904:53-58.

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Clingeleffer, P.R., Smith, B.P., Edwards, E., Collins, M., Morales, N.B., Davis, H., Sykes, S., and Walker, R.R. (2011) Industry puts low-medium vigour rootstocks to the test. Wine and Viticulture Journal. 26-3:72-76.

12. Appendix 4: Staff

Peter Clingeleffer: Supervisor

Brady Smith: Chief Investigator

Arryn Clarke: CSIRO Farm Manager

Norma Morales: Technical Officer